

WHAT IS CLAIMED IS:

1. A magnetic sensor comprising: a free magnetic layer in which the direction of magnetization is changed in accordance with an external magnetic field applied thereto; a fixed magnetic layer in which the direction of magnetization is fixed; a nonmagnetic material layer provided between the free magnetic layer and the fixed magnetic layer; and antiferromagnetic layers fixing the magnetization of the fixed magnetic layer by exchange coupling,

wherein the lengths in a first direction of the free magnetic layer, the nonmagnetic material layer, and the fixed magnetic layer are formed larger than the respective widths thereof in a second direction orthogonal to the first direction, the direction of magnetization of the free magnetic layer is preferentially oriented in the first direction by shape anisotropy,

the fixed magnetic layer has a multilayer structure composed of a second magnetic layer in contact with the nonmagnetic material layer, an interlayer, and a first magnetic layer provided in that order,

the antiferromagnetic layers are provided with an intermediate region having a predetermined length provided therebetween in the first direction so as to be in contact with the first magnetic layer,

the direction of magnetization of the first magnetic layer is fixed by the exchange coupling in the direction crossing the first direction,

the direction of magnetization of the second magnetic layer is fixed antiparallel to that of the first magnetic layer, and

electrical resistance is changed by the direction of magnetization of the free magnetic layer and that of the fixed magnetic layer at the intermediate region.

2. The magnetic sensor according to Claim 1, further comprising a nonmagnetic metal layer at the intermediate region, the nonmagnetic metal layer having the same composition as that of the antiferromagnetic layers, being in contact with the first magnetic layer, having a small thickness as compared to that of the antiferromagnetic layers to form an irregular crystal structure.

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3. The magnetic sensor according to Claim 2, wherein the crystal of the nonmagnetic metal layer and the crystal of the fixed magnetic layer at the intermediate region are placed in an epitaxial or a heteroepitaxial state, and the fixed magnetic layer has an open end surface at a face opposing a recording medium.

4. The magnetic sensor according to Claim 3, wherein the entire nonmagnetic metal layer or a part thereof in the vicinity of the interface with the first magnetic layer of the fixed magnetic layer has a face-centered cubic (fcc) structure, and equivalent crystal planes represented by a {111} plane are preferentially oriented in the direction

parallel to the interface.

5           5. The magnetic sensor according to Claim 3, wherein the nonmagnetic metal layer has a thickness of 5 to 50 Å.

          6. The magnetic sensor according to Claim 3, wherein the entire first magnetic layer of the fixed magnetic layer or a part thereof at least at the intermediate region in the vicinity of the interface with the nonmagnetic metal layer  
10 has a face-centered cubic (fcc) structure, and equivalent crystal planes represented by a {111} plane are preferentially oriented in the direction parallel to the interface.

15           7. The magnetic sensor according to Claim 6, wherein the first magnetic layer of the fixed magnetic layer comprises Co or  $\text{Co}_x\text{Fe}_y$  in which  $y \leq 20$  and  $x+y=100$  are satisfied.

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25 crystal planes represented by a {110} plane are preferentially oriented in the direction parallel to the interface.

9. The magnetic sensor according to Claim 8, wherein the first magnetic layer of the fixed magnetic layer comprises  $\text{Co}_x\text{Fe}_y$  in which  $y \geq 20$  and  $x+y=100$  are satisfied.

5 10. The magnetic sensor according to Claim 3, wherein the first magnetic layer of the fixed magnetic layer at least at the intermediate region has a face-centered cubic (fcc) structure in the vicinity of the interface with the nonmagnetic metal layer, in which equivalent crystal planes  
10 represented by a {111} plane are preferentially oriented in the direction parallel to the interface, and has a body-centered cubic (bcc) structure in the vicinity of the interface with the interlayer, in which equivalent crystal planes represented by a {110} plane are preferentially  
15 oriented in the direction parallel to the interface.

11. The magnetic sensor according to Claim 10, wherein the first magnetic layer of the fixed magnetic layer has a composition represented by Co or  $\text{Co}_x\text{Fe}_y$  (where  $y \leq 20$  and  
20  $x+y=100$  are satisfied) in the vicinity of the interface with the nonmagnetic metal layer and has a composition represented by  $\text{Co}_x\text{Fe}_y$  (where  $y \geq 20$  and  $x+y=100$  are satisfied) in the vicinity of the interface with the interlayer.

25 12. The magnetic sensor according to Claim 11, wherein the Fe concentration of the first magnetic layer of the fixed magnetic layer is gradually increased from the interface with the nonmagnetic metal layer to that with the interlayer.

13. The magnetic sensor according to Claim 3, wherein a value obtained when the difference between the nearest interatomic distance of the nonmagnetic metal layer in an in-plane direction parallel to the interface and that of the first magnetic layer of the fixed magnetic layer at least at the intermediate region is divided by the nearest interatomic distance of the first magnetic layer is in the range of from 0.05 to 0.20.

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14. The magnetic sensor according to Claim 3, wherein the first magnetic layer comprises a magnetic material having a positive magnetostriction constant.

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15. A magnetic sensor comprising: a free magnetic layer; and two laminates provided at two sides of the free magnetic layer, the laminates each having a nonmagnetic material layer, a fixed magnetic layer in which the magnetization is fixed in the direction crossing a first direction, and an antiferromagnetic layer which fixes the direction of magnetization of the fixed magnetic layer,

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wherein, in each of the laminates, the nonmagnetic material layer, the fixed magnetic layer, and the antiferromagnetic layer are provided in that order from the free magnetic layer side, and

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the free magnetic layer and at least one of the laminates form the structure according to Claim 1.

16. The magnetic sensor according to Claim 1, wherein vertical bias means is not provided for orienting the magnetization of the free magnetic layer in the first direction.